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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : D04H

A2

(11) International Publication Number: WO 00/39378

(43) International Publication Date: 6 July 2000 (06.07.00)

(21) International Application Number: PCT/US99/31301

(22) International Filing Date: 30 December 1999 (30.12.99)

(30) Priority Data:
60/114,325 31 December 1998 (31.12.98) US

(71) Applicant: KIMBERLY-CLARK WORLDWIDE, INC. [US/US]; 401 North Lake Street, Neenah, WI 54956 (US).

(72) Inventors: POMPLUN, William, S.; 928 Seven Lakes Drive, West End, NC 27376 (US). JACKSON, David, M.; 9825 Summer Oaks, Roswell, GA 30076 (US). MUMICK, Pavneet, S.; 1202 Taggert Drive, Belle Mead, NJ 08502 (US). CHANG, Yihua; N342 Candlelite Way, Appleton, WI 54915 (US).

(74) Agents: WITHERS, James, D.; Jones & Askew, LLP, 2400 Monarch Tower, 3424 Peachtree Road, N.E., Atlanta, GA 30326 (US) et al.

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: WATER-DISPERSIBLE NONWOVEN FABRICS CONTAINING TEMPERATURE-SENSITIVE OR ION-SENSITIVE POLYMERIC BINDER MATERIALS AND PROCESS FOR MAKING SUCH FABRICS

(57) Abstract

The present invention is directed to a temperature-sensitive or ion-sensitive binder composition containing at least one temperature-sensitive or ion-sensitive polymeric material. The binder composition is either (1) insoluble in water containing greater than about 0.5 weight percent monovalent ions or water having a multivalent ion concentration greater than about 200 ppm multivalent ions, and soluble in water containing less than about 0.5 weight percent monovalent ions or water having a multivalent ion concentration less than about 200 ppm multivalent ions; or (2) insoluble in water having a temperature of greater than about 30 °C, and soluble in water having a temperature of less than about 25 °C. The present invention is further directed to a water-dispersible nonwoven fabric containing the temperature-sensitive or ion-sensitive binder material, which is useful in the manufacture of flushable personal care products. A process for making water-dispersible nonwoven fabrics is also provided.

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WATER-DISPERSIBLE NONWOVEN FABRICS CONTAINING TEMPERATURE-SENSITIVE OR ION-SENSITIVE POLYMERIC BINDER MATERIALS AND PROCESS FOR MAKING SUCH FABRICS

FIELD OF THE INVENTION

The present invention relates to water-dispersible nonwoven fabrics. In a more specific aspect, the present invention relates to water-dispersible nonwoven fabrics, which contain temperature-sensitive or ion-sensitive polymeric binder materials. The present invention also relates to a process for the manufacture of such water-dispersible nonwoven fabrics.

BACKGROUND OF THE INVENTION

Personal care products (such as diapers, sanitary napkins, wipes, wound dressings, bandages, nursing pads and adult incontinence garments) are generally constructed from a number of different components and materials. Principal materials in personal care products are the coverstock (i.e., liner) and the intake (i.e., surge) materials, which are commonly comprised of nonwoven fabrics. For purposes of this application, the terms "nonwoven fabrics", "nonwoven fibrous webs", "fabrics", "fabric webs" and "fibrous substrates" may be used interchangeably and include methods of making such fabrics and webs, such as meltblowing, melt spinning, air laying and wet laying methods.

The surge material must be constructed to receive and absorb various liquids, and the liner material must be constructed to prevent or at least minimize the exudation of such liquids.

Although personal care products are relatively inexpensive, sanitary and easy to use, the proper disposal of a soiled product is not without problems. With greater interest being placed

in protecting the environment today, there is a need to develop materials that are more compatible with the existing and developing water disposal technologies while still delivering the performance which consumers have come to expect and demand. An ideal disposal alternative would be to use municipal sewage treatment and private residential septic systems. Products suited for disposal in sewage systems can be flushed down a convenient toilet and are termed "flushable." To function effectively as liner and surge materials, nonwoven fabrics must maintain their structural integrity and exhibit satisfactory tensile strength when wet or damp. However, if nonwoven fabrics were to lose substantially all of their tensile strength when exposed to water and become dispersible in such water, the disposal problem could be substantially eliminated. These materials could then be conveniently flushed down a conventional toilet system.

Desirably, the nonwoven fabrics possess a number of characteristics, such as softness and flexibility. The fabric is usually formed by wet or dry laying a random plurality of fibers, which are then joined together to form a coherent web. Unfortunately, in an attempt to provide nonwoven fabrics having certain in-use characteristics, prior methods have rendered the fabric non-dispersible in water. For example, nonwoven fabrics have been bonded with fluid-insoluble resins which impart in-use strength. However, such resins impede flushing the fabric by rendering the fabric substantially water insoluble.

With regard to pre-moistened wipes, special problems arise. The wipes, which are used for skin cleansing and are known commercially as towelettes, wet wipes or fem-wipes, are formed from paper or nonwoven fibrous webs treated with a polymeric binder. The binder imparts to the web a degree of wet strength so that the web will maintain tensile strength while being stored in an appropriate liquid medium. However, after the wipe has been used, the binder should be readily weakened when exposed to an aqueous environment, such as a toilet, without clogging the toilet and plumbing.

Various binders have been used in the manufacture of a wipe. For example, wipes have included as a binder an acid-insoluble, alkali-soluble polymeric polycarboxylic acid and functional derivatives thereof wherein the acid is placed in water and enough alkali is added to substantially neutralize all acidic groups prior to applying the binder to the web. The binder-saturated web is dried and then immersed in a low pH medium where the web retains its structural integrity yet will still break up when the wipe is immersed in a sufficiently high pH liquid medium.

Another binder used for a pre-moistened wipe has been polyvinyl alcohol combined with a gelling or insolubilizing agent such as borax. The borax crosslinks at least the surface of the polymer binder before drying the web to give a water resistant web. Such cross-links are reversible, that is, when the concentration of borax is reduced below a certain level, the degree of cross-linking is so low that the binder becomes soluble in water. However, boron-containing solutions are unacceptable for personal care products due to safety concerns.

Yet another water-dispersible nonwoven fabric has used a water-soluble binder comprising a partially neutralized unsaturated carboxylic acid/unsaturated carboxylic acid ester copolymer. A problem with this binder is that to prevent the nonwoven fibrous fabric from disintegrating prior to disposal, the wipe must be maintained in a solution having a pH which may cause irritation to the skin when the wipe is used.

Binders containing carboxylate groups have worked well for making a water-dispersible fibrous web that is, to a limited degree, water soluble, water-dispersible or water-disintegratable in an aqueous environment, provided the water is predominantly void of divalent ions. However, in those areas where the water is "moderately hard", because the water contains divalent ions such as calcium ions or magnesium ions, the wipes do not readily disperse. The water soluble polymeric binder is substantially rendered insoluble by the presence of divalent ions. It is believed that the divalent ions crosslink the binder and prevent the binder from dispersing in the water. The adverse effect that divalent ions

present in the aqueous environment has on the water solubility of the polymeric binder has not been recognized.

Accordingly, there is a need for a water-dispersible binder composition that can be used in a personal care product, such as a wipe, that is safe to use and will be substantially unaffected by the present of divalent ions normally found in moderately hard water.

SUMMARY OF THE INVENTION

Briefly described, the present invention provides a water-dispersible nonwoven fabric, which can be used in flushable personal care products. More specifically, the present invention provides a water-dispersible nonwoven fabric, which contains a temperature-sensitive or ion-sensitive polymeric binder material.

The present invention also provides a process for the manufacture of water-dispersible nonwoven fabrics in which the fibers used to form the nonwoven fabrics are bound together with a temperature-sensitive or ion-sensitive polymeric binder material.

The present invention further provides flushable personal care products, which are made from the water-dispersible nonwoven fabrics provided by the present invention.

These and other objects, features and advantages of this invention will become apparent from the following detailed description.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to binder compositions, which may be used to produce nonwoven fabrics for use in flushable personal care products. The binder compositions possess unique properties, which enable the production of "water-dispersible" products. The binder compositions of the present invention are "ion-sensitive", "temperature-sensitive", or both ion and temperature-sensitive materials. In order to be an effective "ion-sensitive" or "temperature-sensitive" material suitable for use

in flushable personal care products, the binder composition should desirably be (1) functional, i.e., maintain wet strength under controlled conditions and dissolve or disperse rapidly in soft or hard water such as found in a toilets and sinks around the world; (2) safe (not toxic); and (3) economical.

As used herein, the term "ion-sensitive" refers to the solubility and dispersibility of a binder composition, which varies depending upon the amount of monovalent and/or multivalent ions present in an aqueous solution. As used herein, the term "monovalent" refers to ions having a charge of 1, such as Na^+ and Cl^- ions. As used herein, the term "multivalent" refers to ions having a charge of greater than 1, such as Ca^{2+} and CO_3^{2-} ions. In the present invention, the "ion-sensitive" binder compositions remain insoluble in aqueous compositions having a monovalent salt concentration greater than about 0.5 weight percent or a multivalent ion concentration containing greater than about 200 ppm. However, the "ion-sensitive" binder compositions become soluble in aqueous compositions having a monovalent salt concentration less than about 0.5 weight percent or a multivalent ion concentration containing less than about 200 ppm.

In order to be effective as a binder material in flushable products throughout the United States, the ion-sensitive binder compositions of the present invention remain stable and maintain their integrity while dry or in high concentrations of monovalent and/or multivalent ions, but become soluble in water containing up to about 200 ppm Ca^{2+} ions. Desirably, the ion-sensitive binder compositions of the present invention are insoluble in a salt solution containing at least about 0.5 weight percent of one or more inorganic and/or organic salts containing monovalent and/or multivalent ions. More desirably, the ion-sensitive binder compositions of the present invention are insoluble in a salt solution containing from about 0.5 wt% to about 5.0 wt% of one or more inorganic and/or organic salts containing monovalent and/or multivalent ions. Even more desirably, the ion-sensitive binder compositions of the present invention are insoluble in a salt solution containing from about 0.5 wt% to about 3.0 wt% of one or more

inorganic and/or organic salts containing monovalent and/or multivalent ions. Suitable monovalent and/or multivalent ions include, but are not limited to, Na^+ ions, K^+ ions, Li^+ ions, NH_4^+ ions, Cl^- ions, Ca^{2+} ions, Mg^{2+} ions, Zn^{2+} ions, CO_3^{2-} ions, SO_4^{2-} ions, and a combination thereof.

Based on a recent study conducted by the American Chemical Society, water hardness across the United States varies greatly, with $CaCO_3$ concentration ranging from near zero for soft water to about 500 ppm $CaCO_3$ (about 200 ppm Ca^{2+} ion) for very hard water. To ensure polymer dispersibility across the United States, the ion-sensitive binder compositions of the present invention are desirably soluble in water containing up to about 50 ppm Ca^{2+} and/or Mg^{2+} ions. More desirably, the ion-sensitive binder compositions of the present invention are soluble in water containing up to about 100 ppm Ca^{2+} and/or Mg^{2+} ions. Even more desirably, the ion-sensitive binder compositions of the present invention are soluble in water containing up to about 150 ppm Ca^{2+} and/or Mg^{2+} ions. Even more desirably, the ion-sensitive binder compositions of the present invention are soluble in water containing up to about 200 ppm Ca^{2+} and/or Mg^{2+} ions.

Further, as used herein, the term "temperature-sensitive" refers to the solubility and dispersibility of a binder composition, which varies depending upon the temperature of an aqueous solution. In the present invention, the "temperature-sensitive" binder compositions remain insoluble in aqueous compositions having a temperature greater than about 37 °C. However, the "temperature-sensitive" binder compositions become soluble in aqueous compositions having a temperature less than about 20 °C. Desirably, the "temperature-sensitive" binder compositions remain insoluble in aqueous compositions having a temperature greater than about 32 °C, and become soluble in aqueous compositions having a temperature less than about 22 °C. More desirably, the "temperature-sensitive" binder compositions remain insoluble in aqueous compositions having a temperature greater than about 30 °C, and become soluble in aqueous compositions having a temperature less than about 25 °C.

The binder compositions of the present invention comprise at least one polymeric material, which is ion-sensitive, temperature-sensitive, or both. Suitable ion-sensitive and/or temperature-sensitive polymeric materials include, but are not limited to, poly(vinyl alcohol), poly(vinyl methyl ether), hydroxypropyl cellulose, alkyl hydroxypropyl cellulose, such as methyl hydroxypropyl cellulose, and combinations thereof. The binder compositions of the present invention comprise up to 100 weight percent of at least one ion-sensitive and/or temperature-sensitive polymeric material. Desirably, the binder compositions of the present invention comprise from about 25 to about 99 weight percent of at least one ion-sensitive and/or temperature-sensitive polymeric material and from about 75 to about 1 weight percent of at least one "other polymer." As used herein, the term "other polymer" refers to polymer, which do not have either the ion-sensitive or the temperature-sensitive property as described above. More desirably, the binder compositions of the present invention comprise from about 40 to about 95 weight percent of at least one ion-sensitive and/or temperature-sensitive polymeric material and from about 60 to about 5 weight percent of at least one other polymer. Even more desirably, the binder compositions of the present invention comprise from about 40 to about 75 weight percent of at least one ion-sensitive and/or temperature-sensitive polymeric material and from about 60 to about 25 weight percent of at least one other polymer.

Suitable other polymers include, but are not limited to, water-soluble binders such as polyvinyl alcohol, aqueous dispersions of, for example, polyvinyl chloride, polyacrylates, and copolymers of acrylates and methacrylates; polystyrene, styrene-acrylonitrile copolymer, acrylonitrile-butadiene-styrene terpolymer, ethylene-acrylic acid copolymer, ethylene-methacrylic acid copolymer, polyolefins grafted with polar functional groups such as hydroxyl groups, polyacrylates, polymethacrylates, polyvinyl butyral, polyurethanes, polyesters, polyamides, polyvinyl acetate, polyethylene vinyl acetate, ethylene-vinyl alcohol copolymer, and combinations thereof. It should be noted that all grades of

polyvinyl alcohol may be used as the other polymer, including water-insoluble grades. Desirably, the other polymer comprises one or more water-soluble binders such as polyvinyl alcohol, polyvinyl acetate, polyvinyl chloride, polyacrylates, and copolymers of acrylates and methacrylates. The choice and number of suitable other polymers to be blended with the ion-sensitive and/or temperature-sensitive polymeric material is not limited, as long as the resulting binder composition blend possesses desired properties (i.e., ion-sensitive and/or temperature-sensitive solubility, dispersibility in cold water, etc.) suitable for use in water-dispersible products.

In accordance with one embodiment of the present invention, the binder composition comprises from about 25 to about 99 weight percent of at least one polymeric material selected from poly(vinyl alcohol), poly(vinyl methyl ether), and methyl hydroxypropyl cellulose; and from about 75 to about 1 weight percent of polyvinyl acetate.

In some embodiments, it may be desirable to employ one or more additives to the binder compositions of the present invention. Suitable additives include, but are not limited to, antioxidants, antistatic agents, blowing agents, compatibilizers, flame retardants, heat stabilizers, impact modifiers, lubricants, plasticizers, ultraviolet stabilizers, processing aids, dispersants, slip agents, perfumes, colorants, antifoams, bactericides, bacteriostats, surface active agents, thickening agents, fillers, etc., depending on the specific properties desired in the binder composition and products made therefrom. Typically, such additives are incorporated into the binder compositions of the present invention in an amount up to about 10 weight percent of total weight percent of the binder composition.

In one embodiment of the present invention, a plasticizer is incorporated into the above-described binder compositions. Suitable plasticizers include, but not limited to, glycerol; sorbitol; emulsified mineral oil; dipropyleneglycol di-benzoate; polyglycols such as polyethylene glycol, polypropylene glycol and copolymers thereof; decanoyl-N-methylglucamide;

tributyl citrate; and tributoxyethyl phosphate may be added to the solution containing the binder composition.

One advantage of the polymeric binder compositions of the present invention is their relative insensitivity toward divalent cations found in hard water because of the lack of cross-linking sites along the ion-sensitive and/or temperature-sensitive polymeric materials of the compositions. Unlike other binder compositions, the binder compositions of the present invention find versatile applicability to a variety of end uses due to the unique properties of the binder materials.

The binder compositions of the present invention are particularly useful in making "water-dispersible" nonwoven fabrics. As used herein, the term "water-dispersible" refers to the ability of a fabric to disintegrate and/or disperse into pieces of fabric when agitated in water having a low ion content (i.e., water having a monovalent salt concentration less than about 0.5 weight percent or a multivalent ion concentration containing less than about 200 ppm) or in cold water (i.e., below about 25 °C). Desirably, the water-dispersible fabric separates into multiple pieces each having an average size of less than about 50%, desirably less than about 40%, and more desirably less than about 30%, relative to the pre-dispersed size within about 20 minutes, and desirably within about 10 minutes, and more desirably within about 2 minutes in an aqueous environment. As used herein, the term "nonwoven fabric" refers to a fabric that has a structure of individual fibers or filaments randomly arranged in a mat-like fashion. Nonwoven fabrics can be made from a variety of processes including, but not limited to, air-laid processes, wet-laid processes, hydroentangling processes, staple fiber carding and bonding, and solution spinning.

Nonwoven fabrics prepared in accordance with the present invention have good dry tensile strength, but readily disperse in water having a low ion content or a low temperature. The nonwoven fabrics are abrasion resistant and retain significant tensile strength in aqueous solutions, which either contain a high concentration of salt or have a temperature above the "trigger temperature" of the polymeric material. As used herein the phrase

"trigger temperature" refers to the lower critical solution temperature (LCST) or the cloud point temperature of the temperature-sensitive polymeric material. In one embodiment of the present invention, the polymeric material may be further insolubilized by adding an appropriate organic solvent to the water to form a "non-cosolvency effect." As used herein, the phrase "non-cosolvency effect" refers to the formation of a "poor co-solvent" (i.e., a mixture of two or more solvents in which the solubility of a given polymeric material is very low) from two or more "good solvents" (i.e., solvents in which the given polymeric material has good solubility, when the solvents are separate from one another). Suitable organic solvents for forming a non-cosolvency effect include, but are not limited to, methanol and ethanol.

Desirably, the nonwoven fabrics of the present invention are readily dispersible in soft to moderately hard water. As used herein, the term "soft water" refers to water having a divalent ion content of less than about 10 ppm. As used herein, the term "moderately hard water" refers to water having a divalent ion content of from about 10 to about 50 ppm. As used herein, the term "hard water" refers to water having a divalent ion content of more than about 50 ppm. Because of this latter property, the nonwoven fabrics of the present invention are well suited for disposable personal care products such as sanitary napkins, diapers, and dry and pre-moistened wipes, which can be thrown in a flush toilet after use.

The binder materials are particularly useful for binding fibers of air-laid nonwoven fabrics. These air-laid materials are particularly useful for a variety of products including, but not limited to, body-side liners, fluid distribution materials, fluid in-take materials (such as a surge material) and absorbent wrap sheet and cover stock for various water-dispersible personal care products. Air-laid materials are particularly useful for use as a pre-moistened wipe. The basis weights for these air-laid non-woven fabrics will desirably range from about 20 to about 200 grams per square meter (gsm). Surge or in-take materials, which need better

resiliency and higher loft, desirably comprise staple fibers having about 6 denier or greater to make these products. A desirable final density for the surge or in-take materials is between about 0.025 grams per cubic centimeter (g/cc) to about 0.050 g/cc. Fluid distribution materials will have a higher density, desirably in the range of about 0.10 to about 0.20 g/cc using fibers of lower denier.

The nonwoven fabrics of the present invention may be formed of natural fibers, synthetic fibers and combinations thereof. The choice of fibers depends upon, for example, fiber cost and the intended end use of the finished fabric. Examples of suitable fibrous substrates, which can be used alone or in any combination, include, but are not limited to, cotton, linen, jute, hemp, wool, wood pulp, regenerated cellulosic fibers such as viscose rayon, modified cellulosic fibers such as cellulose acetate, or synthetic fibers derived from polyvinyl alcohol, polyesters, polyamides, polyacrylics, etc. Blends of one or more of the above fibers may also be used. In one embodiment of the present invention, a combination of wood pulp and synthetic man-made fibers is used to form a nonwoven fabric. Desirably, the synthetic man-made fibers have a fiber denier of less than about 1.5.

In a further embodiment of the present invention, the nonwoven fabric is formed from relatively short fibers, such as wood pulp fibers. The minimum length of the fibers depends on the method selected for forming the nonwoven fabric. For example, where the fibrous substrate is formed by carding, the length of the fiber should usually be at least about 42 mm in order to insure uniformity. Where the fibrous substrate is formed by air-laid or wet-laid processes, the fiber length may desirably be about 0.1 millimeters to 15 millimeters. Although fibers having a length of greater than 50 mm are within the scope of the present invention, it has been determined that when a substantial quantity of fibers having a length greater than about 15 mm is placed in a flushable fabric, though the fibers will disperse and separate in water, their length tends to form "ropes" of fibers which are undesirable when flushing in home toilets. Therefore, for these products, it is desired that the fiber length be about 15 mm or less

so that the fibers will not have a tendency to "rope" when they are flushed through a toilet. Although fibers of various length are applicable in the present invention, desirably fibers are of a length less than about 15 mm so that the fibers disperse easily from one another when in contact with water, most desirably ranging from about 6 mm to about 15 mm in length. Desirably, the nonwoven fabrics of the present invention have a relatively low wet cohesive strength in tap water and sewer water, so that the fabric will break up readily from the agitation provided by flushing and moving through the sewer pipes.

The nonwoven fabrics of the present invention may be formed from a single layer or multiple layers. In the case of multiple layers, the layers are generally positioned in a juxtaposed or surface-to-surface relationship and all or a portion of the layers may be bound to adjacent layers. The nonwoven fabric may also be formed from a plurality of separate nonwoven fabrics wherein the separate nonwoven fabrics may be formed from a single or multiple layers. The binder may be distributed on the nonwoven fabric as a single application or where there are multiple layers, each individual layer may be separately subjected to a binder application and then combined with other layers in a juxtaposed relationship to form the finished nonwoven fabric.

Another embodiment of the present invention is a process of making a water-dispersible nonwoven fabric. The method includes the steps of contacting the fibrous substrate with an effective amount of the binder composition of the present invention to bind a substantial amount of the fibers and then drying the fabric to form a water-dispersible fibrous fabric. For ease of applying the binder to the nonwoven fabric, the binder may be emulsified, dispersed and/or dissolved in water or another solvent such as methanol, ethanol or the like, with water being the preferred solvent. The binder desirably has from about 1 to about 50 weight percent solids, and more desirably from about 2.5 to about 20 weight percent solids.

The binder material may be applied to the nonwoven fabric by any known process of application, such as by spraying,

dipping, printing, coating or any other technique. When the binder is applied to the nonwoven fabric to retain the integrity of the fabric, the binder is desirably, uniformly dispersed in substantially all of the fabric to cover substantially all of the fiber junctions. Based of the total weight of the nonwoven fabric, desirably the binder may be distributed or "added on" to the nonwoven fabric in an amount of from about 1 to about 50 weight percent, more desirably from about 5 to about 30 weight percent, even more desirably from about 8 to about 25 weight percent, and even more desirably from about 12 to about 18 weight percent.

Once the binder composition is applied to the fabric, the fabric may be dried by conventional means. Once dry, the coherent fibrous fabric exhibits improved tensile strength when compared to the tensile strength of a similar but untreated wet-laid or dry-laid fabric. For example, the tensile strength of the fabric may be increased by at least 25 percent compared to the tensile strength of the untreated fabric. More particularly, the tensile strength of the fabric may be increased by at least about 100 percent and even more particularly the tensile strength of the fabric may be increased by at least about 500 percent as compared to an untreated fabric. However, and quite advantageously, the fabric will disintegrate or is disintegratable when placed in soft to moderately hard water, or cold water, and agitated.

The water-dispersible nonwoven fabrics of the present invention are particularly suitable for use in water-dispersible products. Suitable products include, but are not limited to, wipes, sanitary napkins, diapers, surgical dressings, tissues, and the like. In many products, particularly personal care products, nonwoven fabrics are preferred due to their absorptivity of fluids such as blood, menses and urine. The nonwoven fabrics of the present invention may be incorporated into a variety of body fluid-absorbing products including, but not limited to, sanitary napkins, diapers, surgical dressings, tissues, and the like. The binder compositions of the present invention enable the resulting

nonwoven fabrics to remain intact when contacted by body fluids, since the concentration of divalent ions in the body fluids is above the level of dissolution. The nonwoven fabric retains its structure, softness and exhibits a toughness satisfactory for practical use. However, the binder dissolves and the fabric disperses when brought into contact with water having either a low salt concentration (i.e., below about 0.5 weight percent) or a temperature about room temperature. In one embodiment of the present invention, the nonwoven fabrics are in the form of wipes. The finished wipes may be individually packaged, desirably in a folded condition, in a moisture proof envelope or package in containers holding any desired number of pre-folded sheets and stacked in a water-tight package with a wetting agent applied to the wipe. The wetting agent may comprise, by weight, from about 10 weight percent to about 400 weight percent of the dry weight of the wipe itself. The wipe must maintain its desired characteristics over the time periods involved in warehousing, transportation, retail display and storage by the consumer. Accordingly, shelf life may range from as little as two months to up to two years.

Various forms of impermeable envelopes for containing wet-packaged materials, such as wipes and towelettes and the like, are well known in the art. Any of these may be employed in packaging the pre-moistened wipes of the present invention.

Those skilled in the art will readily understand that the binder compositions and fibrous substrates of the present invention may be advantageously employed in the preparation of a wide variety of products, including but not limited to, absorbent personal care products designed to be contacted with body fluids. Such products may only comprise a single layer of the fibrous substrate or may comprise a combination of elements as described above. Although the binder compositions and fibrous substrates of the present invention are particularly suited for personal care products, the binder compositions and fibrous substrates may be advantageously employed in a wide variety of consumer products.

Further, although the binder compositions are particularly useful in the formation of nonwoven fabrics, the binder compositions may also be used in the formation of woven or knit fabrics, wherein the binder composition is used as a fiber sizing material or a fabric coating material.

The present invention is further illustrated by the following examples, which are not to be construed in any way as imposing limitations upon the scope thereof. On the contrary, it is to be clearly understood that resort may be had to various other embodiments, modifications, and equivalents thereof which, after reading the description herein, may suggest themselves to those skilled in the art without departing from the spirit of the present invention and/or the scope of the appended claims.

EXAMPLES

Preparation of Binder Materials:

Binder No. 1:

This binder was based on polyvinyl alcohol and comprised the following components given in parts by weight:

157.2 parts of 15 weight percent polyvinyl alcohol marketed under the trade designation KP-6 by Nippon Gohsei Company (15 wt% PVOH and 85 wt% water);

42.8 parts of 55 weight percent polyvinyl acetate emulsion marketed under the trade designation VINAC® XX-210 by Air Products, Inc. (55 wt% PVA and 45 wt% water);

192 parts water; and

3.93 parts anhydrous sodium sulfate.

Total solids content: 12.0 weight percent.

To dissolve polyvinyl alcohol in water, the desired amount of poly (vinyl alcohol) powder was added slowly to well-agitated hot water at 80-90°C. The hot slurry was allowed to cool to room temperature with continued agitation. The agitation was continued until all particles were dissolved and the solution was free

of gel. High shear agitation was necessary to ensure complete dispersion when polyvinyl alcohol was added to water, but was not necessary in the subsequent dissolution step.

Alternatively, to dissolve polyvinyl alcohol in water, the desired amount of polyvinyl alcohol was added to water at room temperature with agitation. The agitation was continued until the polyvinyl alcohol was dissolved. In this method, the time factor was more important than high shear to ensure complete solution of the gel particles.

To prepare the binder solution, the desired amount of sodium sulfate was dissolved in water, and this solution was then added to the polyvinyl alcohol solution under agitation, followed by the addition of the polyvinyl acetate emulsion. The viscosity of the final binder composition was about 68 centipoises, but this composition was not stable as phase separation occurred over time upon standing. However, a uniform composition was regenerated with agitation.

Binder No. 2:

This binder was based on polyvinyl methyl ether and comprised the following components given in parts by weight:

7.50 parts polyvinyl methyl ether solution obtained as a 50 weight percent solids solution under the trade designation LUTANOL® M-40 from BASF Corporation;

72.05 parts deionized water; and

20.45 parts polyvinyl acetate emulsion as in Binder No. 1.

Total solids content: 15.0 weight percent.

The polyvinyl methyl ether solution was added to the deionized water at room temperature. After thorough mixing, the polyvinyl acetate emulsion was added with vigorous stirring to obtain a homogeneous mixture. The composition phase separated over time upon standing, but a homogeneous mixture was regenerated upon vigorous agitation. The viscosity of the final binder composition was about 41 centipoises.

Binder No. 3:

This binder was based on methyl hydroxypropyl cellulose and comprised the following components given in parts by weight:

83.0 parts methyl hydroxypropyl cellulose; and

17.0 parts polyvinyl acetate emulsion as in Binder No. 1.

Total solids content: 12.0 weight percent.

The desired amount of methyl hydroxypropyl cellulose powder (marketed under the trademark BENECEL® MP-943 by Aqualon Chemical Company) was added to deionized water at 70-75°C. Under vigorous agitation, the water temperature was allowed to drop to room temperature. The agitation was continued until all of the powder was in solution.

To this solution, the polyvinyl acetate was added with vigorous stirring. The stirring was continued until a homogeneous mixture was obtained. The composition phase separated over time upon standing, but a homogeneous mixture was regenerated upon vigorous agitation. The viscosity of the final binder composition was about 50 to about 200 centiposies.

Binder No. 4:

This binder was based on poly(vinyl methyl ether) and comprised the following components given in parts by weight:

15.0 parts polyvinyl methyl ether solution as in Binder No. 2;

71.4 parts deionized water; and

13.6 parts vinyl acetate–ethylene emulsion marketed under the trademark AIRFLEX® 300 by Air Products, Inc.

Total solids content: 15.0 weight percent.

The polyvinyl methyl ether solution was added to the deionized water at room temperature. After thorough mixing, the

vinyl acetate-ethylene emulsion was added with vigorous stirring to obtain a homogeneous mixture. The composition phase separated over time upon standing, but a homogeneous mixture was regenerated upon vigorous agitation. The viscosity of the final mixture was between about 40 to about 60 centipoises.

EXAMPLE 1

A web containing 75 gsm (grams per square meter) of a mixture of southern softwood Kraft fluff (SSWK) pulp from Rayonier (Jesup, GA) and 6 mm/6 d/f (denier per filament) polyester from KoSa (Charlotte, N.C.) (50:50 weight percent blend) was sprayed with 25 gsm Binder No. 1 to provide a web with an overall basis weight of 100 gsm. This material was found to have some weak areas because of the high viscosity of the binder solution, which prevented good spray coverage of the web. However, this material was found to have instant wetting capability and dispersed in cold tap water.

Another web containing 90 gsm of the same fiber mixture was sprayed with a diluted solution of Binder No. 1 at a level of 10 gsm. Poor spray coverage of the binder was evident from observing the shallow spray cone angle (about 25°). Good bulk was achieved (about 3 mm thickness) and low density (0.03 g/cm^3), which are important for designing a good fluid intake material.

EXAMPLE 2

A web containing 95 gsm CEMFIBER® (Varde, Denmark) polypropylene (6mm/2 d/f) and Rayonier SSWK pulp (50:50 weight percent blend) was sprayed with 5 gsm Binder No. 1 to provide a web with an overall basis weight of 100gsm. Again, poor binder coverage was observed due to shallow cone spray angle. The material was found to be cold water dispersible in tap water.

EXAMPLE 3

A web containing 23 gsm CEMFIBER® polypropylene (6mm/2 d/f) formed on a tissue carrier web was sprayed with 2 gsm Binder No. 1 to provide a web with an overall basis weight of 25 gsm. Poor web formation was observed using straight polypropylene fiber, and the binder was found to be mostly transferred to the tissue carrier web, creating a weakly bonded material.

A second web was formed using 80 wt% CEMFIBER® polypropylene (6mm/2 d/f) fibers and 20 wt% Rayonier SSWK pulp. The web had improved fiber formation, but the high viscosity of Binder No. 1 left one side of the web bonded and the other side only weakly bonded because of poor penetration.

EXAMPLE 4

A web containing 28 gsm rayon fibers (available under the tradename TENCEL® from Acordis Cellulosic Fibers, Inc., Mobile, AL) (6mm / 3d/f) and Rayonier SSWK pulp (75:25 weight percent blend) was sprayed with 8 gsm Binder No. 2 on one side to provide a web with an overall basis weight of 36 gsm. Although the web was "harsher" feeling than webs containing polypropylene, instant wettability was significantly improved using Binder No. 2. The web remained intact when hot water (> than 40°C) was poured onto the web, but when placed in cold tap water, the web dispersed rapidly.

A similar fabric was prepared, but the basis weight of the fiber blend was reduced to 24 gsm and Binder No. 2 was applied at a level of 3 gsm per side. The rayon/pulp fiber makeup with binder applied to both sides was "harsher" to the touch than previous polypropylene based webs.

EXAMPLE 5

A web containing 29 gsm CEMFIBER® polypropylene (6mm / 2d/f) and Rayonier SSWK pulp (75:25 weight percent blend) was sprayed with Binder No. 2, 4 gsm per

side to provide a web with an overall basis weight of 37 gsm. A second fabric was produced keeping the fiber blend basis weight at 29 gsm, but spraying Binder No. 2 at a 7 gsm level on one side only to form a web with an overall basis weight of 36 gsm. Even with the polypropylene fibers added to the fiber blend, the webs seemed somewhat "harsh" to the touch. The added "harshness" was a result of the poly(vinylacetate) additive in Binder No. 2. Both webs stayed intact when warm water passed through them, but broke up rapidly in cold tap water.

EXAMPLE 6

A web containing 31 gsm CEMFIBER® polypropylene (6mm / 2d//f) and Rayonier SSWK pulp (75:25 weight percent blend) was sprayed with 7 gsm of Binder No. 3 on one side to provide a web with an overall basis weight of 38 gsm. Like Binder No. 1, the high viscosity of Binder No. 3 prevented a good spray pattern (about 45°) leading to poor coverage of the binder on the web. This material had good instant wetting capability, but not as good as Binder No. 2 based webs.

EXAMPLE 7

A web containing 31 gsm CEMFIBER® polypropylene (6mm / 2d/f) and Rayonier SSWK pulp (75:25 weight percent blend) was sprayed with 7 gsm Binder No. 4 on one side to achieve a web with an overall basis weight of 38 gsm. A second fabric was prepared reducing the fiber blend basis weight to 27 gsm and spraying both sides of the web with Binder No. 4 at a level of 3 gsm per side, which provided a web with an overall basis weight of 33 gsm. This binder exhibited an excellent spray pattern (cone angle of 90°) and provided good coverage on the web. The webs were also much softer to the touch, which was attributed to the polyvinylacetate-co-ethylene component in Binder No. 4, which is less "harsh" than the polyvinylacetate component in Binder No. 2. Like the webs made with Binder No. 2, webs made with the Binder No. 4 allowed warm water to pass through without destroying the integrity of the web, but when placed in

cold tap water the web quickly disintegrated. These webs were soft to the touch, but did not have adequate integrity. The polyinylmethylether component in Binder No. 4 was responsible for maintaining integrity in warm water, but allowing the web to break up in cold tap water.

EXAMPLE 8

A web containing 90 gsm polyester (6mm / 6d/f) and Rayonier SSWK pulp (50:50 weight percent blend) was sprayed with 5 gsm Binder No. 2 on both sides to provide a web with an overall basis weight of 100 gsm. Binder No. 2 along with the stiff polyester fibers produced a web with good resiliency, high loft (3-4 mm thick), and low density ($0.03 g/cm^3$), which met the desired initial requirements for a fluid intake (surge) material. Upon contact with warm water, the web maintained its resiliency and integrity, but slowly broke up in cold tap water. The polyvinylacetate component in Binder No. 2 was responsible for good web integrity, while the polyvinyl methyl ether provided the trigger mechanism to allow web breakup in cold water.

EXAMPLE 9

A web containing 90 gsm polyester (6mm / 6d/f) and Weyerhauser NB420 fluff pulp (available from Weyerhauser, Federal Way, WA) (50:50 weight percent blend) was sprayed with 5 gsm Binder No. 2 on both sides to provide a web with an overall basis weight of 100 gsm. Like Example 8, the Weyerhauser pulp, with the same combination of polyester fibers and Binder No. 2, provided a web that met the desired initial requirements for a intake (surge) material. The purpose of making webs with two fiber types was to investigate later the effect of fiber type on flushability/dispersibility of composite materials and finally personal care products.

The present invention has been described in detail with particular reference to certain embodiments, but variations and

modifications can be made without departing from the spirit and scope of the invention as defined in the following claims.

CLAIMS

What is claimed is:

1. A temperature-sensitive or ion-sensitive binder composition comprising at least one temperature-sensitive or ion-sensitive polymeric material, wherein (a) the binder composition is insoluble in water containing greater than about 0.5 weight percent monovalent ions or water having a multivalent ion concentration greater than about 200 ppm multivalent ions, and is soluble in water containing less than about 0.5 weight percent monovalent ions or water having a multivalent ion concentration less than about 200 ppm multivalent ions; or (b) the binder composition is insoluble in water having a temperature of greater than about 30 °C, and is soluble in water having a temperature of less than about 25 °C.

2. The binder composition of Claim 1, wherein the binder composition is insoluble in water having a multivalent ion concentration greater than about 200 ppm multivalent ions, and is soluble in water having a multivalent ion concentration of from about 50 ppm to about 200 ppm.

3. The binder composition of Claim 1, wherein the binder composition is insoluble in water having a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a multivalent ion concentration of from about 100 ppm to about 200 ppm.

4. The binder composition of Claim 1, wherein the binder composition is insoluble in water having a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a multivalent ion concentration of from about 150 ppm to about 200 ppm.

5. The binder composition of Claim 1, wherein the binder composition is insoluble in water having a monovalent ion concentration of greater than about 0.5 weight percent and is soluble in water having a monovalent ion concentration of less than about 0.3.

6. The binder composition of Claim 1, wherein the binder composition is insoluble in water having a temperature of from about 30 °C to about 37 °C, and is soluble in water having a temperature of from about 25 °C to about 20 °C.

7. The binder composition of Claim 1, wherein the binder composition is insoluble in water having a temperature of from about 32 °C to about 37 °C, and is soluble in water having a temperature of from about 25 °C to about 22 °C.

8. The binder composition of Claim 1, wherein the binder composition comprises from about 25 to about 99 weight percent of at least one ion-sensitive or temperature-sensitive polymeric material, and from about 75 to about 1 weight percent of at least one other polymer.

9. The binder composition of Claim 1, wherein the at least one ion-sensitive or temperature-sensitive polymeric material comprises poly(vinyl alcohol), poly(vinyl methyl ether), hydroxypropyl cellulose, methyl hydroxypropyl cellulose, or a combination thereof.

10. A water-dispersible nonwoven fabric comprising fibers and the binder composition of Claim 1.

11. A water-dispersible nonwoven fabric comprising:

fibers; and

a temperature-sensitive or ion-sensitive binder composition comprising at least one temperature-sensitive or ion-sensitive polymeric material, wherein (a) the binder composition is insoluble in water having a monovalent ion concentration of greater than about 0.5 weight percent or a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a monovalent ion concentration of less than about 0.5 weight percent or a multivalent ion concentration containing less than about 200 ppm; or (b) the binder composition is insoluble in water having a temperature of greater than about 30 °C, and is soluble in water having a temperature of less than about 25 °C.

12. The nonwoven fabric of Claim 11, wherein the binder composition is insoluble in water having a multivalent ion concentration greater than about 200 ppm multivalent ions, and is soluble in water having a multivalent ion concentration of from about 50 ppm to about 200 ppm.

13. The nonwoven fabric of Claim 11, wherein the binder composition is insoluble in water having a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a multivalent ion concentration of from about 100 ppm to about 200 ppm.

14. The nonwoven fabric of Claim 11, wherein the binder composition is insoluble in water having a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a multivalent ion concentration of from about 150 ppm to about 200 ppm.

15. The nonwoven fabric of Claim 11, wherein the binder composition is insoluble in water having a monovalent ion concentration of greater than about 0.5 weight percent and is soluble in water having a monovalent ion concentration of less than about 0.3.

16. The nonwoven fabric of Claim 11, wherein the binder composition is insoluble in water having a temperature of from about 30 °C to about 37 °C, and is soluble in water having a temperature of from about 25 °C to about 20 °C.

17. The nonwoven fabric of Claim 11, wherein the binder composition is insoluble in water having a temperature of from about 32 °C to about 37 °C, and is soluble in water having a temperature of from about 25 °C to about 22 °C.

18. The nonwoven fabric of Claim 11, wherein the binder composition comprises from about 25 to about 99 weight percent of at least one ion-sensitive or temperature-sensitive polymeric material, and from about 75 to about 1 weight percent of at least one other polymer.

19. The nonwoven fabric of Claim 11, wherein the at least one ion-sensitive or temperature-sensitive polymeric material comprises poly(vinyl alcohol), poly(vinyl methyl ether), hydroxypropyl cellulose, methyl hydroxypropyl cellulose, or a combination thereof.

20. A flushable personal care product comprising the water-dispersible nonwoven fabric of Claim 11.

21. A flushable personal care product comprising a water-dispersible nonwoven fabric, wherein the nonwoven fabric comprises:

fibers; and

a temperature-sensitive or ion-sensitive binder composition comprising at least one temperature-sensitive or ion-sensitive polymeric material, wherein (a) the binder composition is insoluble in water having a monovalent ion concentration of greater than about 0.5 weight percent or a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a monovalent ion concentration of less than about 0.5 weight percent or a multivalent ion concentration containing less than about 200 ppm; or (b) the binder composition is insoluble in water having a temperature of greater than about 30 °C, and is soluble in water having a temperature of less than about 25 °C.

22. The flushable personal care product of Claim 21, wherein the binder composition is insoluble in water having a multivalent ion concentration greater than about 200 ppm multivalent ions, and is soluble in water having a multivalent ion concentration of from about 50 ppm to about 200 ppm.

23. The flushable personal care product of Claim 21, wherein the binder composition is insoluble in water having a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a multivalent ion concentration of from about 100 ppm to about 200 ppm.

24. The flushable personal care product of Claim 21, wherein the binder composition is insoluble in water having a multivalent ion concentration containing greater than about 200 ppm, and is soluble in water having a multivalent ion concentration of from about 150 ppm to about 200 ppm.

25. The flushable personal care product of Claim 21, wherein the binder composition is insoluble in water having a monovalent ion concentration of greater than about 0.5 weight percent and is soluble in water having a monovalent ion concentration of less than about 0.3.

26. The flushable personal care product of Claim 21, wherein the binder composition is insoluble in water having a temperature of from about 30 °C to about 37 °C, and is soluble in water having a temperature of from about 25 °C to about 20 °C.

27. The flushable personal care product of Claim 21, wherein the binder composition is insoluble in water having a temperature of from about 32 °C to about 37 °C, and is soluble in water having a temperature of from about 25 °C to about 22 °C.

28. The flushable personal care product of Claim 21, wherein the binder composition comprises from about 25 to about 99 weight percent of at least one ion-sensitive or temperature-sensitive polymeric material, and from about 75 to about 1 weight percent of at least one other polymer.

29. The flushable personal care product of Claim 21, wherein the at least one ion-sensitive or temperature-sensitive polymeric material comprises poly(vinyl alcohol), poly(vinyl methyl ether), hydroxypropyl cellulose, methyl hydroxypropyl cellulose, or a combination thereof.

30. The flushable personal care product of Claim 21, wherein the flushable personal care product comprises a wipe, a sanitary napkin, a diaper, a surgical dressing, or a tissue.